AUTOMATED DATA COLLECTION TECHNOLOGY APPLICATIONS IN CONSTRUCTION

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ABSTRACT: Real-time control of on-site construction, based on high quality data, is essential to identify discrepancies between actual and planned performances. Additionally, real-time control enables timely corrective measures to be taken when needed to reduce the damages caused by the discrepancies. The focus of the presentation will be on our work, which uses automated data technologies to collect data needed for real time control.

Keywords: Automation; Data Collection; Feedback Control; Control Methods; Monitoring

1. INTRODUCTION

The absence of real-time information limits construction managers' ability to control their projects. As a result, the inherent uncertainty in project activities is increased. Hence, it is not surprising that construction projects are very often late, they exceed their budgets and productivity has remained static, even in developed countries, over the last 20 years. Many construction managers perform only generic and infrequent control because traditional control methods, based on manual data collection, are slow and inaccurate. Even recent developments in automated data collection have not alleviated this situation.

The main technologies that can contribute to real-time control for the research describe below are:

- Barcode – the data in the barcode acts as a reference that the computer uses to look up associated records. These records contain data that are needed to complete the identifying process. In construction, barcode technology has been mainly proposed for: materials tracking or materials waste reduction; monitoring construction progress; and labor control [1-5].
- Radio Frequency Identification (RFID) [1, 6-8]. RFID refers to a branch of automatic identification technologies in which radio frequencies are used to capture and transmit data from a tag, or memory chips, embedded or attached to objects. Compared to barcode, RFID is more advantageous, especially for materials tracking, because it has larger data storage capabilities, it is more rugged and it does not require line-of-sight.
- Global Positioning System (GPS) is a well known and widely used technology that can provide three-dimensional positions. For dynamic positioning, the principle of differential GPS can be applied. Being a satellite-based technology, standard GPS needs a line-of-sight between the receiver and the satellite. As such it cannot normally operate indoors. Recent developments now enable GPS to operate indoors by adding cellular, laser or other technology [9, 10].

The following sections briefly describe some of the major research that we have been engaged in using the above mentioned technologies.

2. ADC-BASED RESEARCH

Labor productivity is an important project performance indicator (PPI). Our research proposes to measure an indirect parameter (worker location) and convert it into control information. The basic concept behind the selection of this indirect parameter is the fact that in order to construct a building element the worker has to be close to it. Therefore, knowing the worker's location at a given time, together with additional information, the activity s/he is performing can be determined. The time and the worker's location are measured using automated data collection (ADC) technology.

In order to determine the feasibility of the above principles, a preliminary model was developed [11, 12] and field experiments were carried out in three building construction sites [12]. At that stage the research used manual location measurement. At the next stage, pilot tests were conducted whereby the locations were properly measured. These tests were conducted on two construction sites using GPS as the location measurement technology. Later, video technology was used to verify the concept, the model and the algorithms.

We are currently conducting simulated experiments using RFID technology to replace the location measurement technology. The idea here, though, is not to measure the location of the workers and to associate it to building elements, but to determine which building element the worker works on at each given time.

3. EARTHMOVING PRODUCTIVITY MEASUREMENT

The principles used for labor productivity measurement served as the basis for the earthmoving operations model, which was implemented in a prototype system for controlling road construction operations [13, 14]. This model was realized in a prototype system and tested in the field for three weeks on a road construction site, using GPS mounted on each of the pieces of equipment performing the controlled activities. The results of the experiments showed that the deviation between the actual productivity and the one calculated by the prototype was relatively low. Unfortunately, to achieve these results a manual intervention at the end of each measurement day was needed – this led to the next stage of the research: the dynamic work envelope (DWE) approach.

According to the DWE approach, instead of associating locations to activities by predetermining work sections, the new approach determines the work envelopes dynamically during its operation, according to the measured locations. Two known algorithms were considered for the DWE algorithm: (a) Minimum Convex Polygon (MCP) and (b) Kernel Density Estimation (KDE) algorithm. An initial field test of the two algorithms was conducted. A GPS receiver was installed on a pickup track and the driver was asked to simulate the work of a compactor by driving slowly forwards and backwards covering a section of a road to be "compacted". During this drive the GPS recorded the measured locations of the pickup track. Back in the lab, these locations were fed into the two algorithms, which calculated the areas represented by these locations.

The results of this experiment were disappointing. These unsatisfactory results led to the development of another DWE algorithm, which had much better results.

4. CONCLUSIONS

Modern construction management requires up-to-date, relevant, and accurate feedback information from the site regarding the actual performance of the project – this information is often unavailable, or requires massive manual work. Even when available, this information reflects events occurring, or long before completed. This unfulfilled need, together with the prospects offered by the rapid improvements in ADC, is the major driving force behind the research described above.

This extended abstract has described an approach to use ADC in order to measure an indirect parameter and then convert it to control information. The results so far prove that automated control is possible, though there is still a need to further develop the algorithms and determine all the factors that affect the results of the automated measurement.

REFERENCES

1. Akinci, B., M. Patton, and E. Ergen. Utilizing Radio Frequency Identification on Precast Concrete Components - Supplier's Perspective. in ISARC - 19th International Symposium on Automation and Robotics in Construction. 2002. Washington DC: NIST - National Institute of Standards and Testing.
2. Chen, Z., H. Li, and C.T.C. Wong, An Application of Bar-Code System for Reducing Construction Wastes. Automation in Construction, 2002. 11(5): p. 521-533.
3. Cheng, M.Y. and J.C. Chen, Integrating Bar-Code and GIS for Monitoring Construction Progress. Automation in Construction, 2002. 11(1): p. 23-33.
4. Echeverry, D. and A. Beltran. Bar-Code Control

of Construction Field Personnel and Construction Materials. in 4th Congress on Computing in Civil Engineering. 1997. Philadelphia, Pennsylvania (USA).
5. Oh, S.W., et al. An Application of PDA and Barcode Technology for the Improvement of Information Management in Construction Projects. in 21st International Symposium on Automation and Robotics in Construction. 2004. Jeju, Korea: Korean Institute of Construction Technology (KICT).
6. Jaselskis, E.J. and T. El-Misalami, Implementing Radio Frequency Identification in the Construction Process. Journal of Construction Engineering and Management, ASCE, 2003. 129(6): p. 680-688.
7. Junichi, Y., A. Eiji, and A. Tatsuo, Parts and Packets Unification Radio Frequency Identification (RFID) Application for Construction. Automation in Construction, 2005. 14(4): p. 477-490.
8. Sawyer-Tom, Electronic Tracking Tags. Engineering News Record (ENR), 2004. 253(23): p. 28-29.
9. Hudson, I.J. GPS Moves Indoors. 2005. http://www.nbc4.com/technology/1394179/'%20+%20clickThru%20+%20'/
10. Kang, S. and D. Tesar. Indoor GPS Metrology System With 3D Probe for Precision Applications. in Proceedings of ASME IMECE 2004 International Mechanical Engineering Congress and RD&D Expo. 2004. Anaheim, CA.
11. Goldschmidt, E. and R. Navon. Automated Real-Time Manpower Productivity Control. in The Eighth International Symposium on Organization & Management of Construction. 1996. Glasgow, UK.
12. Navon, R. and E. Goldschmidt, Can Labor Inputs be Measured and Controlled Automatically? Journal of Construction Engineering and Management, ASCE, 2003. 129(4): p. 437-445.
13. Navon, R. and Y. Shpatnitsky, Field Experiments in Automated Monitoring of Road Construction. Journal of Construction Engineering and Management, ASCE, 2005. 131(4): p. 487-493.
14. Navon, R. and Y. Shpatnitsky, A Model for Automated Monitoring of Road Construction. Construction Management and Economics, 2006. 23(9): p. 941-951.